LLNL-TR-658519

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Sustainment and Recapitalization Requirements for LLNL Site 300 Real Property Utilizing a Novel Interactive Budgetary Interface

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August 7, 2014

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

Sustainment and Recapitalization Requirements for

LLNL Site 300 Real Property

Utilizing a Novel Interactive Budgetary Interface

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July 31, 2014

Abstract

We analyzed and projected the life cycle cost requirements of Lawrence Livermore National Laboratory's (LLNL) Site 300's buildings with respect to sustainment and recapitalization. The current annual capital that is available for Site 300 for sustainment and recapitalization is around $1 million per year. Utilizing the Interactive Budgetary Interface (IBI), we calculate an $8.1 million a year requirement to bring the buildings' Facility Condition Index (FCI) and Recapitalization Needs Index (RNI) to acceptable levels over a period of 20 years. A specific analysis of results suggests an allocation of $4.3 million annually for building maintenance and $3.8 million annually towards building recapitalization.

Nomenclature

FCI: Facility Condition Index. This value represents the total amount of deferred maintenance of a building divided by the building's RPV. The larger the FCI, the worse condition the building is in structurally.

RNI: Recapitalization Needs Index. This value represents the total amount of deferred recapitalization of a building divided by the building's RPV. The larger the RNI, the worse condition the building is in with respect to modernization.

RPV: Replacement Plant Value. The current cost to replace the entire building with a new building of the same functionality and use.

Introduction

With the current budget constraints faced by the national laboratories, resources allocated and prioritization is even more critical. Stakeholders' priorities to justify the program expenditures has made life cycle analysis all the more important. Unfortunately, due to limited funding, infrastructure maintenance and modernization is often suboptimal. This trend tends to cause buildings to increase in deferred maintenance and brings the risk of major or catastrophic failure that may necessitate a capital investment and may also result in additional expenditures as collateral damage. The real question is: How many resources are needed to ensure that infrastructure is properly recapitalized and maintained?

The answer lies in the comprehensive life cycle analysis of the real property. Life cycle analysis is a way to accurately model and project the financial needs of a site's infrastructure. While life cycle analysis also includes the acquisition, operations, and transition and disposition costs, the focus of this project was sustainment and recapitalization of Site 300 buildings.

The goal of this project was twofold. The first goal was to project the necessary budgetary figures needed to properly maintain and modernize the buildings that were selected for modeling. The second goal was the creation of a user friendly, analysis interface, named the Interactive Budgetary Interface (IBI), that allows visualization of the building conditions as they are affected over time by budgetary input. The IBI may be used to supplement presentations and further justify required funding by allowing decision makers to see and actively engage in the generation of the budget needed for Site 300.

Site 300 is home to critical capabilities for the United States nuclear weapons program and has unique explosive testing facilities necessary for the continued certification of the nuclear stockpile as well as the further modernization of the nuclear arsenal.

Approach

In order to calculate the required budget necessary to properly maintain and modernize Site 300 buildings, an analysis interface was designed and created to model the effects of budget input with building condition and modernization.

The IBI calculates of three major metrics: Recapitalization Needs Index (RNI), effective building age, and Facility Condition Index (FCI). The purpose of creating the IBI was to allow for an active illustration of how budgetary inputs affect these three variables. In order to allow for further analysis of the scenarios, models using the three variables were created for: the site as a whole, by building mission dependency category, each mission critical building, and some of the buildings of topical interest.

The first phase of the project was the gathering of raw data to run through the modeling software tools MARS, a Facility Cost Forecast System, and NMI, a time dependent version of MARS [Whitestone Research]. The input data used for the analysis came from the Department of Energy's 2014 Facilities Information Management System (FIMS), as well as the data generated by NMI and MARS [Lufkin, Desai, & Janke, 2005].

With this data collected, we developed the three main models within IBI. The first was the RNI Model. The RNI is a value that represents the overall state of the systems of a building with respect to modernization. Just because a building is in perfect structural condition does not mean it is fully modern for its mission. The building must be modern or have been modernized using recapitalization funds. For the sake of illustration, a walkthrough of the RNI Model for Site 300 will be necessary.

There are several variables that have to be taken into account when creating an interactive model. The equation for RNI is displayed below, using Replacement Plant Value (RPV) and Deferred Recapitalization (Def Recap):

$$\textbf{Net Def Recap}_{(y)}\textbf{/RPV = Def Recap}_{(y-1)}\textbf{/RPV +Required Recap}_{(y)}\textbf{/RPV – Budget}_{(y)}\textbf{/RPV} \qquad (1)$$

In order to use this equation, the user must have access to the RPV and current deferred recapitalization values and the building decay rate.

RNI is a percentage of the RPV value of the building(s) found by taking the total net deferred recapitalization costs to the current year and then dividing that number by the total RPV. This is the output of the equation as represented as "**Net Def Recap$_{(y)}$/RPV.**" The next factor in the equation is the total deferred recapitalization of the previous year divided by the RPV as represented by "**Def Recap$_{(y-1)}$/RPV**". This factor carries over any deferred recapitalization costs that were not canceled out by the budget input in the previous iteration of the equation. The next term is the required recapitalization divided by the RPV as represented by "**Required Recap$_{(y)}$/RPV.**" The required recapitalization is calculated by taking the current building value and multiplying it by the decay rate for that specific building. Below, the equation for required recapitalization is given:

$$\textbf{Required Recap = (1-Def Recap/RPV) x decay rate} \tag{2}$$

The budget, represented in the equation as "**Budget$_{(y)}$,**" is the independent variable of this equation. When the budget is divided by the RPV, the resulting number is the amount the RNI will decrease when the other two terms, **Required Recap$_{(y)}$/RPV** and **Def Recap$_{(y-1)}$/RPV**, are factored in. The user can manipulate the budget and observe its effects on the RNI.

A building's RNI increases at a geometric rate. To find the decay rates, each building was examined in the NMI data to determine which Whitestone building model it had been mapped from. Once this was determined, the Whitestone building models and their decay rates were located in the MARS data. In order to represent Site 300 as a whole, the depreciation rates of all the buildings were weighted, using the percentage of RPV represented in each mission tier, and then averaged together. It should be noted that this averaging does contribute some error into the RNI Model; however, the purpose of the model was not to generate an exact number, but rather to illustrate the general needs of Site 300 and the trends in building decay with respect to time and budget.

Specific data that was needed to create the RNI Model, in addition to the decay rates, were the deferred recapitalization and RPV. The RPV can be found by summing together all of the building RPVs for a given instance. The deferred recapitalization can be generated by creating a scenario in NMI that includes all of the buildings to be included in the given interface model. We then estimate costs for that scenario for 20 years and run a query for the Recapitalization Costs by Site by Year. The Cumulative Recap is the total deferred recapitalization up to that year. A similar methodology was also applied for the other interface models using RNI.

The Effective Age Model is used to calculate the effective building age, which is fundamentally tied to the RNI. To illustrate how to use this model, a description of the Site 300 effective age calculation is needed.

For the effective building age calculation, use the RNI in Equation 1 for the building(s) and the depreciation rate(s) used in the RNI Model.

$$\textbf{Effective Building Age = LN(1-RNI)/LN(1-r)} \tag{3}$$

The above equation is used to calculate the present effective building age for each building.

The FCI Model is created using the following formula:

$$\textbf{Current FCI = FCI previous year – (yearly budget – yearly sustainment)/RPV} \qquad (4)$$

The data required to perform this calculation consists of: current Deferred Maintenance (DM), RPV, and yearly sustainment. DM and RPV can be found in FIMS. Yearly sustainment can be found by generating the deferred maintenance and sustainment report for the specified scenario in NMI. Note there is an error in NMI that comes from yearly sustainment. This error should be used in creating error bars. Current FCI is calculated by factoring in the FCI of the previous year. In addition, there is a yearly sustainment cost that is required to hold the FCI steady. If the annual budget does not meet or exceed the yearly sustainment cost, the Current FCI will increase. In this equation, the annual budget is the independent variable. Note that the yearly budget and yearly sustainment are both divided by the RPV value. This converts both factors into equivalent FCI values.

It should be noted, a discrepancy exists regarding RPV. The RPV differs in NMI and FIMS. For the purpose of this project, FIMS data was used for RPV. Regarding yearly sustainment and its error, for Mission Critical building totals, the sustainment and errors were added by building. For the other two mission dependency categories, Mission Dependent Not Critical and Not Mission Dependent, the sustainment and error was found by running the sustainment report by mission tier grouping scenarios. The totals for the site were calculated by summing the three mission dependency categories' terms for sustainment and error.

For the present analysis, the majority of the budget calculations were performed using the overall site and mission tier interface models. Three calculations were done with these models. The first was the amount of money needed to keep the FCI at 0 and the RNI/Buildings Age at 0. The second calculation was to amount of money to bring the fore mentioned variables to the target values of effective operations. The third was simply the amount of money needed to stabilize the FCI and RNI at their current values.

The IBI

Why was the IBI created? While there are several excellent life cycle analysis programs, none of them have an interactive budget input that allows for the analysis of various funding scenarios. The purpose of this project was to generate the optimal funding scenario for Site 300 buildings. This calculation and its method can clearly be applied to other facilities and sites. Seeing the future need for these calculations led to the creation of the IBI, which can, with minimal effort, effectively model other sites and locations represented in the FIMS database. In addition, due to the current budget issues facing the national laboratories, providing a tool for upper management to visualize life cycle analysis results is important. The justification for proper funding for the maintenance and upgrading of infrastructure is a clear priority. The IBI can easily be utilized by any person with basic Excel experience. This interface could provide support and validation for additional funding requests to stakeholders.

Results

The IBI is used to generate the data to validate the required funding to meet LLNL's Site 300 FCI and RNI goals.

Site 300 Buildings	Projected Total Annual Funding ($k)	Projected FCI Annual Funding ($k)	Projected RNI Annual Funding ($k)
Hold Conditions Steady	7,429	4,167	3,262
Reach Target FCI and RNI in 20 years	8,078	4,278	3,800
Reach 0 FCI and RNI in 20 years	14,478	5,128	9,350
Mission Critical Buildings			
Hold Conditions Steady	2,635	1,143	1,492
Reach Target FCI and RNI in 20 years	2,688	1,038	1,650
Reach 0 FCI and RNI in 20 years	4,249	1,299	2,950
Mission Dependent Not Critical Buildings			
Hold Conditions Steady	2,661	1,645	1,016
Reach Target FCI and RNI in 20 years	3,364	1,814	1,550
Reach 0 FCI and RNI in 20 years	5,962	2,062	3,900
Not Mission Dependent Buildings			
Hold Conditions Steady	1,939	1,378	560
Reach Target FCI and RNI in 20 years	1,884	1,424	460
Reach 0 FCI and RNI in 20 years	4,116	1,766	2,350

Table 1. Projected Funding Results

A funding gap becomes quite evident when considering that the total amount of money currently allocated is approximately $1 million annually for the maintenance and the modernization of all Site 300 buildings.

Validation and Verification

The calculated results may be impacted by the following:

- FIMS data
- MARS and NMI calculations
- Building Selection

A previous Monte Carlo study [Miller, Mattimore, 2011] based on variability of these input parameters suggest a range of error in the results. Generally a well calibrated NMI/MARS produces calculations accurate within +/- 2-3%.

Future Work

Calculations and analysis suggest that an increase in Site 300's sustainment and recapitalization budget is urgently needed. With this in mind, a prioritization process must be rigorously pursued to allocate money to buildings that are critical to the fundamental mission of Site 300. Fortunately such a decision-making framework exists already and is currently in use by both sites at LLNL. The processes can be integrated with NMI, MARS, IBI, and the Deferred Maintenance Prioritization Process [Lori Delage] to support decision making.

The IBI could easily be used for calculations for other NNSA sites that have data in FIMS. The IBI was created as a framework to be applied to further funding issues as well as to serve as a basis for the construction of a more in-depth interface.

Conclusion and Recommendations

IBI has shown that with the current budget constraints, more effort must be placed into modeling the infrastructure to inform good decision making. More optimal utilization of funds to prolong the life of the facilities currently used for ground breaking research and development projects, as well as for national security and defense must become a priority. Site 300 has the unique testing facilities present on the site that are critical components in the continued certification and modernization of the nation's strategic nuclear deterrent. IBI results and calculations indicate that the funding for sustainment and recapitalization should be increased to $8.1 million annually – with $4.3 million allocated to reducing the FCI of Site 300's buildings and the remaining $3.8 million to be used to modernize the site's buildings.

Acknowledgments

There are several people who efforts simply must be recognized. Without their hard work and advice, this project would not have been possible.

Lisa Clowdus – For being an awesome mentor throughout the internship and providing constant help and a genuine interest in the project.

Bernie Mattimore – For the many hours spent teaching me about life cycle analysis and vetting the equations used in the interface.

Jon Miller at Whitestone Research – For his critical help in the construction and validation of the RNI interface equation along answering several critical project questions.

John Scott – For a detailed tour of Site 300.

Cliff Shang – For the incredible opportunity to work for WCI and for supporting an undergrad who certainly at times felt a little overwhelmed.

And thank you to Mrs. Edwards and my Livermore family for all their support!